Problem Statement

Microplastics and the special category of microfiber plastics are small pieces of plastic; the generally accepted definition for microplastics is plastics smaller than 5 mm (Andrady 2011, Wright et al. 2013, Wagner et al. 2014). Microfiber plastics, which are the synthetic fibers from synthetic and fleece and polyester clothing, can be released during washing. Patagonia estimates that each time a synthetic fleece jacket is washed, 1.7 grams of microfibers are released; researchers at Plymouth University estimated that 700,000 microfibers are released with each load of laundry (Paddison 2016). Because wastewater treatment plants aren't designed to remove the microfibers, they enter the ocean and have been reported to make up the majority of the microplastics found in coastal British Columbia waters and clams (Davidson and Dudas 2016; Christensen 2017). To reinforce the magnitude of this problem, it has been estimated that there will be more plastic in the oceans than fish by 2050 (The World Economic Forum 2016).

Many of the environmental studies on microplastics are from about 2010 on and are marked by a large degree of uncertainty as to how harmful they are to ecosystems because of the knowledge gaps on **exposure** (i.e. how much marine organisms come into contact with what type of microplastics) and **effect** (i.e. the consequences of the exposure). With respect to the effects, there is the potential for chemical and physical toxicity. The chemicals that make up the microplastic may themselves be toxic and chemicals from the ocean (such as pesticides and metals) may attach to the plastics (Ogata et al. 2009; Rochman et al. 2013). Physical effects include internal abrasions and blockage of the digestive tract, which can lead to starvation and ultimately result in death (Wright et al. 2013).

The research I propose to work on is to characterize how much microplastics are in regional mussels (**exposure**). This would be the first step in a larger project to contribute to the knowledge gaps listed above. I would continue the work with my current graduate student whose thesis research is being designed to determine the **effects** of microfibers on growth and reproduction of bivalves. This work in our lab will support an emerging relationship with the USGS and ideally lead to research partnerships around the question of microplastic exposures and effects on marine invertebrates.

Description of Intended Work and Methods

The focus of this research will be on characterizing how much and what types of microplastics have accumulated in blue mussels (*Mytilus sp*.) at a minimum of seven locations in Whatcom County. The sites will match those used for ongoing monitoring studies using mussels and conducted by the Washington State Department of Fish and Wildlife (Lanksbury et al. 2017). The sites will include a range of adjacent landuses, including urban (e.g. South Bay trail in Bellingham), industrial (e.g. Cherry Point), and rural (e.g. Clark's Point). Other sites will be selected opportunistically (where there are mussels that can be accessed). The number of mussels collected at each site will depend on availability, but a target

number would be 20 mussels per site. Mussels tissues will be chemically dissolved (digested) and microplastic type determined as described by Davidson and Dudas (2016) and Khoironi et al. (2018). Briefly, mussels will be shucked, and the tissue digested in 30% H_2O_2. Visual analysis with a microscope will be used to measure size and determine shape of any microplastics released from the tissue. The mass of microplastics will be determined and normalized to the mass of digested tissue. Additional characterization will include SEM/EDX imaging and elemental mapping as described by Khoironi et al. (2018) and available at WWU through the Scientific Technical Services. The SEM/EDX will provide information on the chemical composition of the accumulated microplastics. The majority of the supplies needed for this work are already available in my lab; the largest expense is labor, which would be covered by this summer research grant if awarded.

Expected Results and Outcomes

Although I expect microfibers to dominate the accumulated microplastics, I will test whether there are differences based on adjacent land-use. As this is exploratory work, it is not clear whether 20 mussels per site would be enough to determine statistical differences in accumulation patterns in mussels, but the results of this work can be used in to inform future collection so that statistical power needed for these types of comparisons. The types of plastic in mussels will also inform my graduate student's thesis work as we will need to select what type of microplastics she exposes her bivalves to. Finally, a better understanding of the chemical composition of the microplastics will direct how much we focus future toxicity tests on chemical or physical toxicity as our primary concern.

Project's Importance

This work would be the first step for my lab in better understanding the consequences (effects) of microplastics to marine organisms. I recently attended a Society of Environmental Toxicology and Chemistry (SETAC) National conference and participated in Microplastic Research Interest Group discussions. There is interest in this type of work and the potential for several regional collaborations with government and private partners. The work planned with my graduate student to provide knowledge of how much microplastic it takes to have effects on bivalve growth and reproduction will further define our role in assessing the consequences of microplastics in the marine environment. This understanding of how much of a substance it takes to cause an effect in an organism is typically the first step in toxicity experiments, yet there is little published literature that has considered these relationships, which makes an assessment of risk challenging. I believe we have the expertise in my lab and with regional collaborators to be important contributors to this emerging concern. Finally, this type of work is interesting and exciting to the students I work with. There will be many opportunities for undergraduate students to participate in microplastic work as senior theses. I have a strong record of involving undergraduate students in research (with 5 posters presented by at the recent SETAC conference: 3 undergraduate student first authors, 2

graduate student first authors, 1 graduate student co-author and 13 undergraduate student co-authors) and this project will provide the foundation for many more research opportunities for WWU students.

References Cited

Andrady, A.L. 2011. Microplastics in the marine environment. *Marine Pollution Bulletin* 62:1596-1605.

Christensen K. 2017. Guess What's Showing Up In Our Shellfish? One Word: Plastics. The Salt: What's on Your Plate. Accessed 7/5/18: https://www.npr.org/sections/thesalt/2017/09/19/551261222/guesswhats-showing-up-in-our-shellfish-one-word-plastics

Davidson K., and S.E. Dudas. 2016. Microplastic ingestion by wild and cultured manila clams (*Venerupis philippinarum*) from Baynes Sound, British Columbia. *Archives of Environmental Contamination and Toxicology.* 1(2):147-56. doi: 10.1007/s00244-016-0286-4.

Koironi A., S. Anggoro, and Sudarno. 2018. The existence of microplastic in Asian green mussels. IOP Conf. Series: Earth and Environmental Science. 131. doi :10.1088/1755-1315/131/1/012050

Lanksbury J., B. Lubliner, M. Langness, and J. West. 2017. Stormwater Action Monitoring 2015/16 Mussel Monitoring Survey. WDFW Report Number FPT 17-06. Accessed 11/5/18 https://wdfw.wa.gov/publications/01925/wdfw01925.pdf

Ogata, Y., H. Takada, K. Mizukawa, H. Hirai, S. Iwasa, S. Endo, Y. Mato, M. Saha, K. Okuda, A. Nakashima, M. Murakami, N. Zurcher, R. Booyatumanondo, M.P. Zakaria, L.Q. Dung, M. Gordon, C. Miguez, S. Suzuki, C. Moore, H.K. Karapanagioti, S. Weets, T. McClurg, W. Smith, M.V. Valkenburg, J.S. Lang, R.C. Lang, D. Laursen, B. Danner, N. Stewardson and R.C. Thompson. 2009. International Pellet Watch: global monitoring of persistent organic pollutants (POP) in coastal waters. 1. Initial phase data on PCBs, DDTs, and HCHs. *Marine Pollution Bulletin* 58(10): 1437-1446.

Paddison, L. 2016. Single clothes wash may release 700,000 microplastic fibres, study finds. The Guardian. Accessed: 11/5/18.https://www.theguardian.com/science/2016/sep/27/washing-clothes-releaseswater-polluting-fibres-study-finds

Rochman, C.M., E. Hoh, T. Kurobe and S. J. Teh. 2013. Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress. *Scientific Reports* 3:3263. doi:10.1038/srep03263.

The World Economic Forum. 2016. *The New Plastics Economy: Rethinking the Future of Plastics*. Accessed 11/5/18 http://www3.weforum.org/docs/WEF_The_New_Plastics_Economy.pdf

Wagner, M., C. Scherer, D. Alvarex-Munoz, N, Brennholt, X. Bourrain, S. Buchinger, C. Grosbois, J. Klasmeier, T. Marti, S. Rodriguez-Moñaz, R. Urbatzka, A.D. Vethaak, M. Winther-Nielsen and G. Reifferscheid. 2014. Microplastics in freshwater ecosystems: What we know and what we need to know. *Environmental Sciences Europe* 26:12

Wright, S.L., R.C. Thompson and T.S. Galloway. 2013. The physical impacts of microplastics on marine organisms: A review. *Environmental Pollution* 178:483-492.